Verification of Electronics and PMT Calibration in SNO

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Accurate measurement of the physics processes in the SNO detector requires a chain of calibrations and calculations to convert the raw measured quantities (e.g. charge in the fired photomultiplier tube) to a full description of the physics process (e.g. energy). In this chain of calibrations, the electronic (ECA) and photomultiplier tube calibrations (PCA) are at the most fundamental level. If the ECA and PCA calibrations are not applied correctly to the data, one would get erroneous higher level calibrations in optical constants and energy.

In ECA, an on-board electronic pulser in the SNO front-end card (FEC) is used to measure the transfer functions and the pedestals. The rise time of the PMT pulses and the leading-edge discrimination used in the electronics lead to a timing dependence on the PMT anode charge. Calibration of this effect and the establishment of a common time offset reference are performed in the PCA by running a nearly isotropic pulsed light source, whose light is generated by a nitrogen laser, at various light intensities and source positions.

We have performed extensive systematic checks on this timing calibration, which is essential in correctly reconstructing the events seen in the SNO detector. The tests we have performed included:

1. Comparison of the standard ECA/PCA algorithms to a second completely independent algorithm to demonstrate their consistencies;
2. Variation of the calibrated laser prompt light timing on a FEC-by-FEC basis for different source locations;
3. Variation of the calibrated laser prompt light timing on a FEC-by-FEC basis for different source intensities;
4. Investigation of detector triggering bias on the timing calibration;
5. Investigation of the laser hardware bias by testing the timing calibration at different laser wavelengths;
6. Consistency check of the reconstruction on ^{16}N γ-ray calibration source position;
7. Variation of the timing calibration over time.

Figure 1 shows the timing variation of the prompt laser light for all the FEC in the SNO electronics system in a calibration run for which the laser source is at the center of the detector. It is clear that the spread in the calibrated time is much less than the 5-cm systematic accuracy ($\sim$0.25 ns equivalent) in the deployed source position.

This analysis has demonstrated that the standard timing calibration algorithm being used is adequate for physics analysis. Our suite of tests are now being implemented as standard quality assurance checks for future calibration runs.

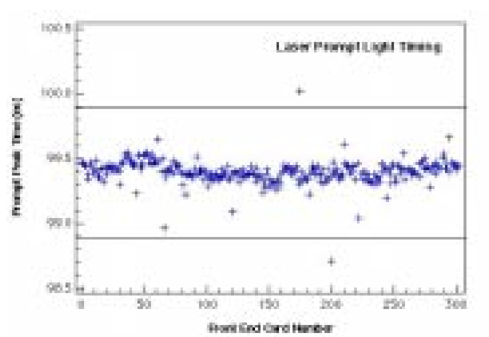

Figure 1: Variation of the calibrated laser prompt light timing on a FEC-by-FEC basis. A 1-ns box is drawn to demonstrate the consistency the ECA and PCA calibration algorithms.